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How Highway Departments Utilize High-Early-Strength Cement

Avoiding Long Detours in Mountain Roads One of Valuable Uses—Increasing Use in Metropolitan Areas—Is Cost Offset by Advantages?

THE practice of 43 state highway departments has been determined in a survey made by CONCRETE, concerning the extent to which they have made use of high-early-strength cement in concrete roads and highway structures.

Many States Use High-Early-Strength Cement

No less than 28 states out of the 43 reported have had experience with the use of high-early-strength cement. Four of the remaining 15 states have had satisfactory results with the use of increased quantities of ordinary portland cement in special cases where short gaps were to be filled in, or in bridge decks, or at intersections, or where for any reason the early opening to traffic was desirable.

Where Early-Strength Cement Is Used

In enumerating the purposes for which high-early-strength cement is employed, those most frequently mentioned, approximately in the order given, include (1) reduction of the curing period, (2) elimination of long detours (mainly in mountainous regions), (3) closing short gaps in pavements, (4) paving of intersections, and (5) paving roads in regions of heavy traffic. The first of these—reduction of the curing period—is, of course, the main object sought in the remaining four.

Elimination of Detours

When high-early-strength cement is employed in order to eliminate long detours, or where no detours are available, as frequently happens in mountainous areas, the practice is to keep the subgrade on one side of the center line open to controlled traffic while the other side is being concreted. On the following day the newly placed concrete is opened to controlled traffic and the remaining half is concreted. On first impression it might be thought that this same arrangement could be employed with ordinary portland cement. This *could* be done, but it would not be practicable, because too much time would elapse between the concreting of adjacent halves of the road. In consequence, the contractor would be compelled to complete half the roadway over the entire length of the contract, then return to the point of beginning and start the other half. This would necessitate moving his equipment along the entire contract a second time, greatly increasing his labor costs. By using high-early-strength cement he can place adjacent halves on successive days, thereby requiring only one move of equipment.

That high-early-strength cement has definite value in the elimination of long detours in mountainous regions is well demonstrated from the fact that such use is mentioned in the replies from states such as Massachusetts, Maryland, Pennsylvania, New Jersey, North Carolina, Alabama, Texas and Washington. Most of these states are required to deal with the problem of building highways through mountainous or hilly regions.

Steady Improvement in Results

Among the states just mentioned, Washington has the most rugged topography to deal with. It will therefore be interesting to read the comments of T. G. McCrory, chief engineer of the Department of Highways of that state, who says: "We have used high-early-strength cement quite extensively during the past four years, using it where we have to open our pavements in a short time to take care of traffic. High-early-strength cement has worked out very satisfactorily for us. There has been a steady improvement in the results obtained."

Twenty-eight state highway departments have had experience in the use of high-early-strength cement. Some highway engineers and contractors believe the extra cost of this cement is more than offset by cost reductions in other directions—for instance, in the reduced curing time — but apparently the majority continues to think of high-early-strength cement as best suited to special cases where extra expenditure is justified because of the need for the least possible interference with traffic.—The Editors.

"In Maryland," says C. B. Bryant, engineer of materials, "we have used several thousand barrels of high-early-strength cement in regular paving work as the means of eliminating the cost and inconvenience of detouring or re-routing traffic."

The elimination of detours is discussed also by John D. Waldrop, state construction engineer for the North Carolina State Highway Commission. "High-early-strength cement," he says, "is used in places damaged by heavy rains, on approaches to bridges, on regular stretches of road in order to eliminate the cost and inconvenience of bad detours, and on sections where it is impossible to detour traffic during the period of construction."

L. M. Dinsmore, office engineer for the Alabama State Highway Department, tells of the use of high-early-strength cement "where detours are long," and on intersections. S. H. Probert, office engineer for the Oregon State Highway Commission, reports having "used this method to good advantage at several points, but not for any entire project."

In Metropolitan Areas

As might be expected, states having large concentrations of population, and consequent problems in traffic congestion, are prominent among those employing high-early-strength cement in highway work.

For instance, Samuel Eckels, chief engineer of the Pennsylvania Department of Highways, says: "We specify high-early-strength concrete on a number of our regular paving contracts where we find it economical in view of the location, traffic, and population served. We have also specified high-early-strength concrete on certain sections of projects in order to reduce to a minimum the curing period after the completion of the pavement. Each project is considered separately and no definite rule is established. The contractor is given the option of using either high-early-strength cement or richer mixtures of ordinary portland cement."

"In Illinois," says C. M. Hathaway, engineer of construction, Division of Highways, "considerable paving work has been done with high-early-strength cement and the results were very satisfactory, particularly in reducing the curing time and thereby eliminating the inconvenience of detours."

R. B. Gage, chemical engineer, New Jersey State Highway Commission, mentions the question of added cost. "High-early-strength cement has been used in considerable quantity," he says, "for paving work where it is desired to use the pavement at an early date. In such instances the extra cost of this cement appears to be justified. The quality of the concrete thus constructed has in all cases been satisfactory."

E. C. Lawton, construction deputy, New York State Division of Highways, mentions the use of "a limited amount of high-early-strength cement for paving work, particularly in congested areas where it is necessary to interfere with traffic as little as possible."

R. W. Coburn, construction engineer, Massachusetts Department of Public Works, states that they "are taking advantage of high-early-strength cement for regular paving work as a means of reducing the curing time and lessening the inconvenience to traffic."

Curiously enough, although Ohio has several areas with heavy concentrations of population, this state has not tried the use of high-early-strength cement, according to Neal Moler, assistant engineer, bureau of construction.

Higher Early Strength

The trend toward *higher* early strength in the manufacture of ordinary portland cement is reflected by Gibb Gilchrist, state highway engineer, Texas State Highway Department. "We have used high-early-strength cement quite extensively," he says, "where unusual traffic conditions were encountered, and we were interested in opening the pavement at an early date. However, we have a very unusual condition in Texas, in that a number of our standard brands of cement give us ordinary 28-day strength in 3 and 4 days."

Used at End of Project

An interesting use of high-early-strength cement is described by M. E. Cox, contact engineer for the State Highway Board of Georgia, who says: "We have used high-early-strength cement in our regular paving for short stretches only, in order to open the road at a much earlier date. Our practice is to use this cement during the last few days of concreting operations on a project, so that we may open the entire road within 2 or 3 days after finishing the job. From our experience we find that the use of this cement in eliminating the cost and inconvenience of detours is well worth the extra cost."

H. D. Palmore, state highway engineer for the Kentucky Department of Highways, tells of the use of high-early-strength cement in stretches not exceeding ½ mile in length. H. S. Kerr, chief engineer for the Utah State Road Commission, mentions "satisfactory" results with the use of this cement. G. H. Henderson, chief engineer, Rhode Island State Board of Public Roads, tells of the use of "high-early-strength concrete on short stretches, with success." Hubert E. Sargent, chief engineer and commissioner of Highways, Vermont Department of Highways, mentions the use of high-early-strength cement "in villages and special places only."

Only one of the 28 states having experience with high-early-strength cement has taken an unfriendly attitude toward this cement. This comes from New Hampshire. "We have tried out the advantages of high-early-strength cement for regular paving work," says Frederic E. Everett, commissioner and state engineer, "but we find no object in using this material."

Use of Ordinary Portland Cement

Wisconsin is one of the states that prefers to use ordinary portland cement, in the belief that the concrete pavement can be opened to traffic as soon as the berms and ditches are finished. After stating that no high-early-strength cement had been used, E. L. Roettiger, assistant construction engineer, Wisconsin Highway Commission, says: "Some high-early-strength concrete has been placed on intersections and in completing some of the jobs. Standard portland cement was used. We have found that generally the pavement is available for use as soon as the necessary berms and approaches are built."

A somewhat similar thought is expressed by William J. Titus, chief engineer, Indiana State Highway Commission, although some high-early-strength cement has been used in that state. "High-early-strength cement has been employed in some instances," he says, "in order that a short section of pavement might be opened to traffic as promptly as possible. This practice with us has not been extensive, par官ticuarly because ordinary portland cement concrete can usually be opened to traffic within about 10 days, which period we believe is desirable for curing. There is also the matter of time necessary to finish the shoulders and ditches and slopes on the usual paving job."

Arkansas is another state in which an increased amount of normal portland cement is employed in preference to high-early-strength cement, according to W. W. Zass, engineer of construction, State Highway Commission. "Where a pavement is to be opened to traffic at an early period," he says, "it has been our practice to use normal portland cement, increasing the cement content per cubic yard from 10 to 15 per cent."

The use of high-early-strength concrete, obtained "by designing special mixes with regular cement," is also reported by Seward Mason, testing engineer, Montana State Highway Commission. A. T. Lobdell, chief of the bureau of roads and bridges, Nebraska Highway Commission, tells, likewise, of the use of extra amounts of normal portland cement in several cases.

The Question of Cost

Not all highway engineers are, as yet, convinced that the extra cost of high-early-strength cement is fully offset by the reduced cost of curing, the shorter time required for completion, and other known advantages.

In Maine, however, Lucius D. Barrows, chief engineer of the State Highway Commission, supplies the interesting information that "in some cases contractors have elected to furnish high-early-strength cement in order to reduce the curing time otherwise required." He continues: "We have not used this cement in our regular concrete paving work. We have occasionally used it for short sections in order to provide for crossing over the pavement, as at intersecting roads. We have also used it to some extent on bridge work."

R. B. Gage, chemical engineer, New Jersey State Highway Commission, has previously been quoted to the effect that the extra cost of high-early-strength cement appears to be justified wherever the earlier opening of the pavement is a matter of importance.

A similar view is expressed by C. M. Hathaway, engineer of construction, Illinois Division of Highways, who adds: "As a general proposition, on our state-wide program, the price of high-early-strength cement hardly justifies its use except at important intersections, pavement gaps, and so on, where it is vital that traffic is caused the least inconvenience."

On the other hand, M. E. Cox, contact engineer, State Highway Board of Georgia, has previously been quoted to the effect that "from our experience we find that the use of this cement in eliminating the cost and inconvenience of detours is well worth the extra cost."

T. H. Cutler, chief engineer, Missouri State Highway Department, after telling of some use of high-early-strength cement, expressed the opinion that "its actual advantages and economy are somewhat limited in paving work."

H. Allen, engineer of materials, State Highway Commission of Kansas, adds: "We have tried high-early-strength cement on small sections which we did not want to keep closed longer than 72 hours, and have found it to be very satisfactory. We are of the opinion, however, that its use in regular paving work would not be justified.

"In California," says C. H. Purcell, state highway engineer, "a section of pavement employing high-early-strength cement has recently been completed. As a rule our detours are in good condition, after being oiled, so that high-early-strength pavements are not always justified as a matter of service to traffic."

Effect of Low Temperature?

R. M. Brennan, chief clerk, Engineer Department, District of Columbia, raises the question of retarded gain in strength during low temperatures. He says: "The Engineer Department has used a considerable amount of high-early-strength cement for paving work. It has proved of particular value when used during ordinary summer temperatures, but its value when used during low temperatures has been questioned due to the marked effect that low temperature has in reducing its gain in strength. This has been evident from results of tests of field specimens."

Use Is on Increase

Considering these discussions as a whole, it appears that the use of high-early-strength cement in highway work is on the increase, but that the highway engineers and contractors who believe the extra cost of the cement is offset by cost reductions in curing and in other ways are still in the minority.

Products Plant Develops Reinforced Concrete Beam Unit

Employed Over Openings—Same Unit Forms Belt Course to Reinforce Concrete Masonry Walls

A reinforced concrete "beam tile" is a distinctive masonry unit developed for the local market by the products manufacturing division of the Penniman Concrete and Material Co., of Dallas, Texas.

A rectangular trough is made by cutting out obstructing shells and webs of regular concrete units to within about 1½ in. of the bottom of the units, and grouting in the bottom part of the core holes remaining. This is done while the units are green.

These troughs or "beam tile" have the appearance of standard units when laid in the wall in the usual way. They are made in both 8-in. and 12-in. widths. When used as belt courses the trough-like units are laid in a course around the wall, steel reinforcing rods are placed, and the trough is filled with concrete.

Such courses serve most economically as lintels over narrow openings. Often a continuous belt course is placed near the top of a wall, immediately under the bearing joists, thereby providing a substantial bearing for the joists as well as forming a continuous tie around the building. A belt course of this nature serves also as a fire stop.

A special end piece is made for closing the ends of lintels which are not parts of a continuous belt course. Separate lintels of a depth equal to two units are made by placing a second course of units, in an inverted position, over the first course.

Use Structural Plywood Forms on Illinois River Bridge

THE construction of the east approach of the Cedar Street bridge across the Illinois River at Peoria, Ill., is of interest to the concrete construction industry because of the excellent results obtained through the use of plywood for the form work.

Work on this bridge was started some years ago, but because of a shortage of funds the structure was left half finished, with nothing done on the east approach. In the autumn of 1931 the contract for this east approach was awarded to the J. L. Simmons Company, Bloomington, Ill., although concrete work was not started until March, 1932.

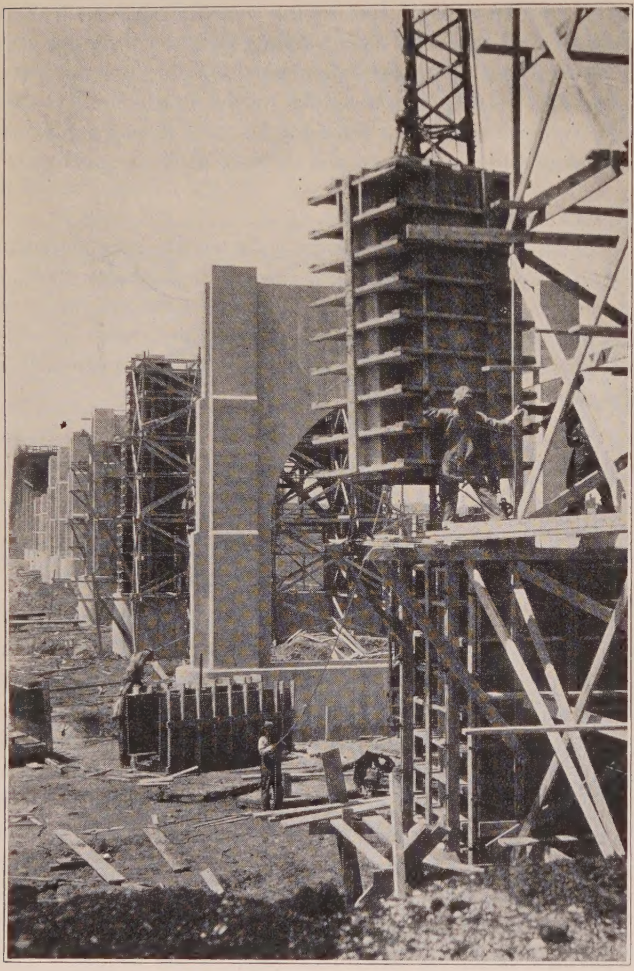

Figure 1. Hoisting plywood form units into place in construction of the Cedar Street bridge, Peoria, Ill. Observe smooth finish on second pier

Complicated Form Work

As one of the illustrations indicates, this approach consists of a number of reinforced concrete piers having large arched openings in the diaphragm walls. The outer supporting columns of the piers are given an architectural treatment which, combined with the arches, complicated the form work.

Smooth Finish and True Edges Obtained—Reduces Labor Costs on Form Work and on Concrete Finish

Figure 1 shows the manner in which this form work was built in the job carpenter shop in large units, transported to the pier site and then hoisted into place. The form unit there shown in the act of being hoisted is intended for one of the outside columns of the pier. Figure 2, similarly, shows a form panel for the arched diaphragm wall being lifted into place.

Plywood Used as Structural Material

The greater part of the plywood used on this contract was $3/4$-in. 5-ply stock. For the curved face of the arches a $3/8$-in. 3-ply stock was used, to facilitate bending of the material to conform with the curve.

As shown in the illustrations, the plywood was used structurally, in the same manner that form boards are employed in ordinary wooden form construction. The larger and lighter sheets of plywood, however, greatly speeded up the work of form construction, thereby reducing form labor costs. This may readily be appreciated from the fact that the plywood sheets were supplied in sizes such as 3 by 8 ft. Cleats, liners and studding, mainly of 2 by 4-in. and 2 by 6-in. dimension lumber, are employed in the usual way.

Character of Plywood

In the manufacture of these plywood sheets, logs of Douglas fir, ranging in length from 6 to 16 ft., are rotary-cut in power lathes, the thin sheets which are to form the individual plies of the finished product being peeled off by a sharp knife. Prior to this operation the logs have been softened by boiling. The thin sheets are then cut to the proper size and are dried, after which an odd number of layers are cemented together with a water-resistant glue. By alternating the direction of the grain in successive layers, any tendency toward splitting or warping is overcome. The finished plywood sheets are oil-treated at the factory.

Make Form Units from Shop Details

In Figure 2, in addition to the form units in place and being lifted into place, several additional units may be seen on a small car on an industrial track that formed a part of the construction plant equipment. These units had just been brought up from the job carpenter shop, where all form units were made up in accordance with detailed shop drawings. Units requiring repairs were returned to the carpenter shop for such repairs. The form units shown in Figures 1 and 2 were being used for the seventh time.

The industrial track was put to many uses in moving materials along the series of bridge piers, and its installation was found to be well justified.

One of the characteristic results obtained from the use of form material of a type such as plywood is the smooth finish on the concrete when the forms are stripped. The smoothness of the finish is well illustrated by the second pier in Figure 1. Because of this fact, the labor ordinarily required in clipping off fins, and in rubbing and patching, is largely or wholly eliminated. The contractor's superintendent estimated the saving on this account at 3½ to 4 cents per square foot of contact form surface.

Acknowledgments

The plywood used on this contract is a Douglas fir product manufactured by the Oregon-Washington Plywood Company, of Tacoma, Wash., and sold under the trade name of "Lock-tite." It was supplied through a local lumber dealer. O. R. Callbeck was the contractor's superintendent in charge of the work for the general contractor, the J. L. Simmons Company, of Bloomington, Ill.

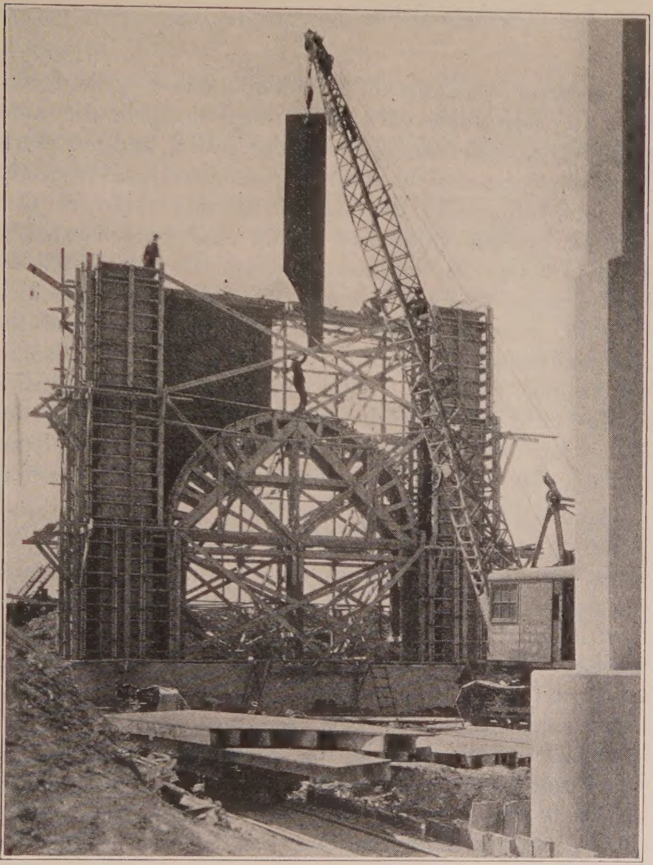

Figure 2. Wall form units being lifted into position from car that brought them from carpenter shop

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A Billion Dollar Industry in Concrete Construction

Quantity of Concrete Based on Cement Shipments —Value Based on Cost of Concrete Alone

The quantity and value of concrete placed annually in the United States may be estimated with a fair degree of accuracy from the quantity of cement shipped from cement mills. Very little cement is either exported or imported, so that total mill shipments represent very closely the actual quantity of cement used in making mortar and concrete, the latter including the concrete employed in the manufacture of concrete products.

Information is available on the number of square yards of concrete roads, streets and alleys built each year, and from these records the number of cubic yards of concrete used in paving work can be closely estimated. The assumption may be made that paving concrete utilizes, on the average, about 6 sacks (1.5 bbl.) of cement per cubic yard of concrete, and that other concrete averages about 5 sacks (1.25 bbl.) per cubic yard.

Cost Per Cubic Yard

The cost of concrete in the pavement or structure may be estimated from the prices charged by commercial ready-mixed concrete plants, inasmuch as it is believed that commercial plants can deliver ready-mixed concrete at a price no higher than the cost of mixing on the job. Taking the average quoted prices for the last few years, but disregarding the present tendency to cut prices for the sake of getting business, the average delivered price may be assumed as $6.50 per cubic yard for paving concrete and $6.00 for all other concrete. To this should be added an average cost of $1.50 for placing and finishing paving concrete and $2.00 for all other concrete, bringing the total cost, in place, to $8.00 per cubic yard for all concrete.

Worth Billion Dollars in Normal Year

By combining the foregoing figures the quantity and value of concrete work can be closely approximated, as shown in the table.

ESTIMATED QUANTITY AND VALUE OF CONCRETE CONSTRUCTION

	1929	1930	1931
Cement shipped from mills (number of bbl.)	169,437,000	158,744,000	126,465,000
Cu. yd. of concrete used in concrete highways	20,600,000	24,000,000	24,900,000
Cu. yd. of concrete used in concrete streets and alleys	10,500,000	8,400,000	5,300,000
Cu. yd. of concrete used as base for other types of pavements, and in buildings, bridges, dams, concrete products, and miscellaneous uses	98,200,000	88,100,000	65,000,000
Total cu. yd. of concrete	129,300,000	120,500,000	95,200,000
Value, in place, at average normal price of $8.00 per cu. yd.	$1,034,400,000	$964,000,000	$761,600,000

It should be noted that the estimated value of concrete construction, amounting in normal years to around one billion dollars, represents the cost of the concrete in place, and that alone. It does not include the cost of form work, nor the cost of steel reinforcement in the case of reinforced concrete, nor anything except the bare cost of the material and labor involved in mixing, distributing, placing and finishing the concrete itself.

Coming Conventions

October 3-7—National Safety Council, twenty-first annual congress. Washington, D. C.

February 20-23, 1933—American Concrete Institute, twenty-ninth annual convention. Chicago, Ill.

Co-ordination of Basic Principles of Concrete Mixtures

Ready-Mixed Concrete Creates Demand for Exact Control of Mixtures—Required Laws of Mixtures—Feret's Researches Long Misunderstood

IV—Needed Laws of Mixtures and Known Fundamentals

By JOSEPH A. KITTS
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The first positive demand for an exact knowledge of the physics and technology of concrete mixtures was introduced by the advent of the commercial concrete plant supplying "ready-mix," "transit mix," "certified mix," stock pattern or "custom built" concrete, when and where wanted by the buyer. This new manufacturing industry has increased (in the United States) from 25 major plants in 1925 to more than 1,000 at the end of 1931, and has given an entirely new aspect to the requirements of concrete-making in material handling, in measuring equipment, and particularly in the routine pretesting of materials and technological control of production. — The Author.

THE varieties of concrete mixtures demanded of ready-mixed concrete plants are innumerable (see Part 3, in July issue of CONCRETE). Proportions are specified by loose-moist, loose-dry and dry-rodded bulk volume, by absolute volume, and by weight. Piece-work rather than mass production is the general rule. The successive batches may be specified as follows, as a practical example:

The buyer demands not less than a cubic yard of concrete for each cubic yard billed him; the producer aims to deliver a cubic yard for each one billed, and not more. Thus the correct yield must be predetermined from the absolute volumes of the ingredients, and arbitrary proportions by bulk volume or weight must be converted to absolute volume as the basic measure. The first batch delivered must be correct in all respects for the specified strength, must be within ½ in., plus or minus, of the specified slump, and within ½ of 1 per cent of the specified volume, and all of these conditions must be fulfilled to the satisfaction of the buyer when the mixer truck arrives on the job, possibly 10 miles away. Trial batch or cut-and-try methods are, therefore, out of the question.

The usual change of mixtures, batch by batch, as shown in the preceding schedule, requires that batching of aggregates and cement be done by weighing as the only practical means of meeting all the conditions, as well as the most accurate means. Thus, arbitrary proportions by any method of measure must be converted first to the actual absolute volumes in a unit of concrete and then to the corresponding weights. The weight proportions of any specified concrete must be calculated often in 15 or even 10 minutes. In view of the several maximum sizes of aggregate demanded of the ready-mix plant, several size separations are carried and the usual mix is made up of three or more sizes. These are new combinations of requirements, introduced by the ready-mix industry, for which there were no adequate criteria of accomplishment.

In order to meet this first demand for a complete con-

TYPICAL BATCH PRODUCTION SCHEDULE

Batch No.	For job	Batch volume, cu. yd.	Max. size aggregate	Slump, inches	Compressive strength, lb./sq. in., at given age	Specified proportions and measure	
1	A	1½	3/16	"Grout"	2,000 @ 28 days		
2	B	4	1½	5		1:2½:5	loose-moist
3	C	3	¼	8½		1:2	dry-rodded
4	D	3	⅞	7½	2,200 @ 28 days		
5	E	4	2½	3		1:9	loose-dry
6	F	3½	1	7	2,500 @ 10 days		
7	G	4	¾	8		1:2:4	weight
8	H	4	1½	6		4.5	sacks per cu. yd.
9	I	4	1½	5½	4,000 @ 28 days		
10	J	3	1¼	------		1:6 dry-rodded, W/C = 1.00	
11	K	3	⅜	8½	1,500 @ 28 days		
12	L	2½	1¼	6½	2,000 @ 24 hours		

crete technology, it has been necessary to co-ordinate the known fundamentals of mixtures and to determine essential complementary laws and empirical equations of mixtures, for given conditions of aggregates, cement, and consistency of mix, satisfying the following specifications:

Requirement (1)—Law of the cement content for any strength, maximum size of aggregate, and slump of concrete;

Requirement (2)—Law of the corresponding water-cement ratio for any strength;

Requirement (3)—Law of the corresponding aggregate content;

Requirement (4)—Law of the optimum fineness modulus for the given cement content and maximum size of aggregate;

Requirement (5)—The grading equation for the given fineness modulus and maximum size of aggregate; and

Requirement (6)—The law of yield of combinations of ingredients.

It should be appreciated that the accomplishment of these requirements has been the result of many men groping assiduously, for more than a generation, for these laws most abstrusely concealed by the many variables involved and by the encumbrance of that ancient idea of measure, the bulk volume. A review of concrete mixture research, with the foregoing specifications of needed laws in mind, will serve to present the known fundamentals of the various theories of proportioning, recent complementary discoveries, the development of co-ordination, and it will show the abstruse character of the research and the many important relations and inter-relations yet to be clarified.

REVIEW OF MIXTURE RESEARCH

Arbitrary Ratio Proportions

Mixtures in arbitrary proportions, such as 1:1:2, 1:1½:3, 1:2:4, and 1:3:6, by bulk volume, have been studied since ancient times. Since weighing devices became available the same arbitrary proportions, by weight, have been studied. In fact, it has been a common error to make no distinction between certain numerical proportions, by weight, and the same numerical proportions by bulk volume. The research data, comprising millions of tests, have been more confusing than definite, due largely to the inherent indefiniteness of the bulk volume (and weight) measures, and to a general lack of data of water content, flowability of mix, yield of concrete, and physical characteristics of the ingredients.

Since experience had shown that there was nothing fundamentally correct in the fixed proportion of one part of fine aggregate to two parts of coarse, other simple ratios have been studied; but, in turn, they show no merit in any mere combination of numerals.

Another step was an attempt to regulate the grading of the fine and coarse aggregates to fit the arbitrary mix, but the tendency of the aggregates to segregate in handling offsets somewhat the benefit of the initial grading, and the maintenance of a uniform grading in aggregate production has proved impractical.

Another procedure in the use of the arbitrary ratios has been to state the ratio of cement to total aggregate, such as 1:4, 1:5, and 1:6, and leave the proportioning of the individual aggregate to the engineer or contractor.

These arbitrary proportions comprehend only two general size classifications of aggregates, "fine" and "coarse," whereas today we are confronted with the proportioning of from two to six or more sizes. They do not comprehend a definite structure and consistency of mixture and, likewise, point to no definite laws of strength and consistency. The general indications, however, have been that strength increases with the cement content, with the maximum size of aggregate and for change from sloppy to plastic mixtures.

None of the previously specified laws have been definitely indicated by the many years research of arbitrary proportions by bulk volume and weight.

Proportioning with Regard to Voids in Aggregates

Filling the voids in the coarse aggregate with fine aggregate and the voids in the fine aggregate with cement, with the object of securing the densest mix, is one of the oldest theories of proportioning. There are various modifications of this idea and it is well established that, for a given cement content and consistency, the strength increases with increase of density of the concrete. Although the voids theories of proportioning have been studied considerably, since 1900, they show no definite formula of strength. It is obvious, however, that the filler-to-voids relations must be considered in the production of impermeable and durable concrete.

The idea of the filler-to-voids relations is the first concept of a physics of concrete mixtures.

Feret's Scientific Approach in Concrete Research

The noted French authority on concrete physics, René Feret, may well be called the father of modern thought in concrete research. As chief of the laboratory of Ponts et Chaussees at Boulogne, about 1890 and subsequently, Feret introduced the use of the absolute volume as the basic measure of aggregates and cement in the study of the densities, strengths, and quantity of water for gauging of mortars (see *Annales* des Ponts et Chaussees, 1892, II, pp. 1, 35, 57, 77, 117, 501); derived equations for proportions of water for mortars of normal and other consistencies; graphically represented the granular structure of aggregate mixtures and the corresponding densities and strengths of concretes therefrom (see *Tome* IV, pp. 73, 103 and 309, Commission des Methodes d'Essai des Materiaux de Construction, 1895) derived an equation of strength based on the concentration of cement in the space occupied by cement, water and air voids (see *Bulletin* de la Société d'Encouragement pour l'Industrie Nationale, 1897, II); and, in many other ways, introduced scientific methods of tests and analyses of the physical relations obtaining in concrete mixtures.

Feret found that the strength for a given cement content increased with the density of the concrete; the density increased with the maximum size of the aggregate, with the coarsness of grading, and with gauging of water to slightly less than that for plastic consistency; and the density decreased constantly with further increase of water. The density (compacité) of concrete was defined by Feret as the total absolute volume of solids in a unit volume of concrete. He also found that the strength was a function of the ratio of cement to the space occupied by cement, water and air voids, or, of the concentration of cement in the space occupied by cement, water, and entrapped air.

Feret's equation of strength, applying particularly to mortar, is:

$$S = J\left[\frac{c}{1 - (c + s)} - 0.1\right] \quad . \; . \; . \; . \quad (9)$$

and that applying to both mortar and concrete is

$$S = K\left[\frac{c}{1.0 - a}\right]^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (9a)$$

in which S is the compressive strength, c, s, and a are the absolute volumes of cement, sand and aggregate, respectively, in a unit volume of mortar or concrete, and J and K are constants depending upon the age of the concrete, the quality of cement and aggregates, the consistency, slump, or flow of the mix, and on conditions of production control.

Feret instituted the calculation of the "elementary volumetric composition" and the density of the mixtures, and thus established the fundamental basis of measure of ingredients and, also, an important physical measure of mixtures.

Basis of Yield of Combinations

The "elementary volumes" in a unit volume of fresh concrete consist of the absolute volume proportions of cement, aggregate, water, and entrapped air voids. To illustrate, a mix will be stated in (1) the usual nominal bulk volume ratio, (2) in the corresponding proportions for a unit volume of concrete showing cement and aggregate by usual bulk measure, and (3) in the corresponding "elementary volume" proportions, as follows:

	(1) Nominal ratio bulk volume	Proportions for unit vol. of concrete (2) Proportions by bulk volume	(3) Proportions by elementary volume	
Cement	1	0.264	0.129	$= c$
Sand	1½	0.396	0.264	$= a$
Gravel	3	0.792	0.459	
Water	--	0.140	0.140	$= w$
Air voids	--	--------	0.008	$= v$
Total	--	1.592	1.000	

The symbols c, a, w, and v are the absolute volumes of cement, aggregate, water and air voids, respectively, in a unit volume of concrete. Thus

$$c + a + w + v = 1.0 \quad . \; . \; . \; . \; . \; . \; . \quad (10)$$

Feret has thus shown that the absolute volume is the basic measure of ingredients, and has provided, in Equation 10, the fundamental law of the yield of combinations satisfying our *Requirement* (6). His corresponding equation of density is:

$$d = 1.0 - (w + v) = c + a \quad . \; . \; . \; . \quad (11)$$

Feret introduced the use of the absolute volume in 1892. It has been applied subsequently by most, if not all, authorities on concrete proportioning, as a means of determining the yield of combinations. However, its practical application as the basis of measure has been considered either an abstract theory or applicable only in laboratory research. Its use as the practical and basic measure of proportions was not advanced until 1929 (see *Proceedings*, American Concrete Institute, 1929, pp. 741-750).

(To Be Continued)

Causes of Cracking or Crazing

British Engineer Thinks Excess Water, Imperfect Curing and Faulty Design Are Main Sources of Trouble

The following letter from Norman A. Grandage, of The Contract & Works Supply Co., near Huddersfield, England, contains interesting comments on the causes of cracking or crazing of concrete. As Mr. Grandage points out, thirty years ago the cement itself may have had to share the blame for these defects; but today, with our greatly improved cement, the fault rests largely with excessive mixing water, lack of proper curing, and faulty design. The letter from this correspondent follows:

In sending my cheque for renewal of subscription to Concrete, I should like to express my appreciation of the valuable work you are carrying out in the cause.

The Institution of Structural Engineers, of which I am an associate member, is doing useful work in this country, by ventilating the various factors involved in the production of uniform concrete.

One of the difficulties we have to face is the lack of recognition, on the part of contractors and others, that concrete can be, and should be, a definite structural unit, which may be stressed to certain limits, with the usual tolerances, just as with other structural media, such as steel and cast iron.

I am interested in cement manufacture, and should like to emphasize the point that, whilst we, as cement makers, have gone to the greatest trouble in producing a cement that is definitely *uniform*, so many users fail to take advantage of this vital feature, and obtain divergences in the quality of the ultimate concrete, by ignoring the other important factors.

It would be interesting to hear the opinions of some of your readers on the vexed question of cracking in concrete. I attribute the following, in order of probability, as causes of cracking or crazing:

1. Amount of water used in gauging and curing:

   (a) *Overwatering*, as so commonly met with, even in these days. Obviously, given quantities of ballast, sand, cement and water, will occupy a certain volume. If, on gauging, there is excess of water, over and above that required for the hydration of the lime salts in the cement, this excess will be eliminated by evaporation, the volume of the concrete must be reduced, and internal stresses set up in the body of concrete, with resultant cracks.

   (b) *Imperfect curing*. The complete hydration of the lime salts takes up a period of time, and water lost by evaporation, must be made good by the maintenance of a moist condition. This factor is often overlooked.

2. *Faulty design*. The omission of suitable expansion joints in reinforced concrete members, e. g., in the case of a tank which is subject to alterations of high and normal temperature conditions. Allowance for expansion and contraction was provided, but was insufficient.

3. *Cement*. Whilst this was a definite source of cracking thirty years ago, it is a very unlikely cause with any modern cement of repute. A cement which shows only 0.50 to 1.00 mm. expansion on the Chatelier test for soundness, can be ignored as a possible cause of cracking.

Norman A. Grandage, A. M. I. Struct. E.,
The Contract & Works Supply Co.

The Hey, Marsden,
Near Huddersfield, England.

Concrete Lagging Lines Open Caisson for Skyscraper Foundation

New Concrete Specialty Employed in Second Unit of Field Office Building in Chicago—Reduces Quantities of Excavation and Concrete

AN innovation in the construction of caissons for skyscraper column foundations has been successfully tried in the second unit of the new Field Building, now being erected at La Salle and Adams streets, Chicago.

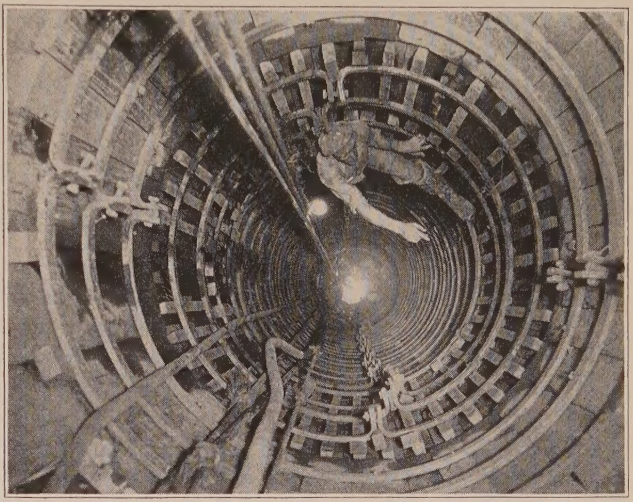
To form these cylindrical concrete piers, open wells or caissons are dug to the desired depth—usually to bedrock, which is reached at a depth of approximately 100 ft. below the street level of Chicago's Loop district.

How Caissons Are Lined

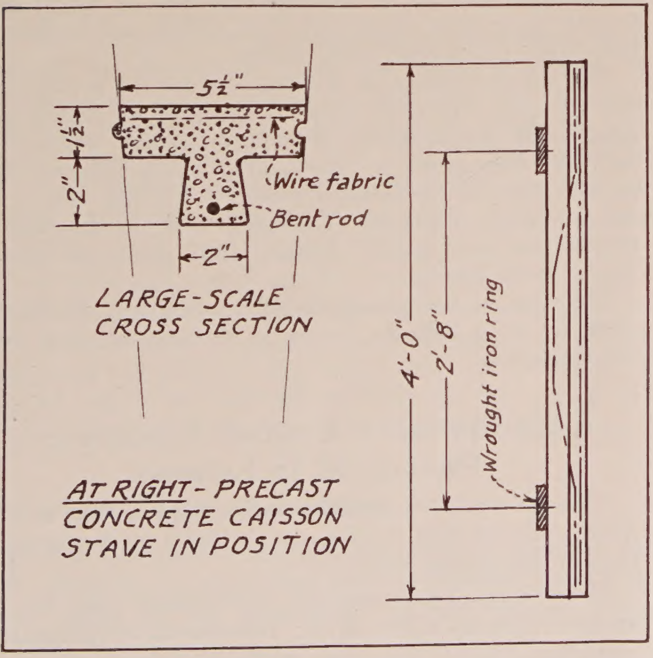
As excavation proceeds in unit depths of 4 or 5 ft., the soil is ordinarily supported by a wood lining composed of uniform lengths of tongue-and-groove staves. These are placed upright against the earth so as to line the well completely. A series of barrels open at both ends and set on top of each other would be somewhat similar in appearance. Wrought iron rings about ¾ in. thick by 4 in. wide are fastened on the inside, two per set of staves, so as to hold the latter firmly against the earth and prevent its caving.

The Reinforced Concrete Lagging

In place of this customary wood lining, the innovation tested in one caisson of the Field Building consisted of specially designed reinforced concrete lagging. The cross section of an individual unit resembles the letter "T." The tops, or flanges, of these T's were placed against the earth. Tongues and grooves along their edges enable them to interlock longitudinally. The lower portion or stem of the T projects inwardly and is of increasing width as it extends away from the flange. This dovetail feature locks the lagging securely into the later-placed concrete of the pier proper.



Interior view of caisson, showing reinforced concrete lagging in position


5½"
1½"
2"
Wire fabric
Bent rod
2"
LARGE-SCALE CROSS SECTION
AT RIGHT- PRECAST CONCRETE CAISSON STAVE IN POSITION
4'-0"
2'-8"
Wrought iron ring

Details of concrete stave, or lagging, used as caisson lining

Such a lining is intended not only to become an integral part of the concrete cylinder but also retains the earth as excavation proceeds, and acts as a form for the concrete which is afterward deposited in the well.

Excavation and Concrete Reduced in Quantity

In this way a saving in excavation is effected, as it is necessary to dig a well of diameter equivalent only to that of the specified concrete cylinder, rather than of increased diameter to allow for the wood lining, which is entirely independent of the concrete pier, considered structurally.

Moreover, the precast concrete lagging, functioning as a part of the pier, reduces the volume of filled-in concrete required to complete the cylinder.

Other Savings Realized

Additional economy is effected in the metal rings. As these are placed against the stems of the T's, their diameters are reduced, with an attendant shortening of circumferences.

These combined savings in excavation, filled-in concrete and rings more than compensate for any difference in price and ease of handling in favor of wood. By using lightweight aggregate in the concrete lagging the items of handling and transportation are benefited. A substantial cost reduction in each caisson is apparent. In a structure involving numerous caissons—there are 168 required for this building—the expected saving would be considerable.

Acknowledgments

This precast concrete lagging was invented by S. G. Martin, civil engineer, who has a patent application on file in Washington. Graham, Anderson, Probst and White are architects for the Field Building, and their chief structural engineer is M. Gunderson. C. A. Wikle represents this firm on the job. The George A. Fuller Co. has the general contract and is represented by D. H. McGorrisk. The caisson and foundation work is being carried on under sub-contract by the W. J. Newman Co., under the superintendence of Wm. J. McGregor. The Federal-American Cement Tile Co., whose engineer is A. B. Shenk, manufactured the concrete lagging.

Development of Feeder Roads Urgent —Cutler

The progress made in building the system of main highways of the United States has not been duplicated in the feeder roads that serve the main highways, declares T. H. Cutler, president of the American Road Builders' Association.

"What work remains to be done on the highway system? Additional routes must be provided to care for unusual traffic conditions. Many routes must be widened. Safety features must be built into existing roads. Belt lines must be built. Pavements built years ago to fit traffic conditions then existing must be reconstructed. Gaps in the main system must be filled in. All this work and more remains to be done on the main systems besides the work of meeting unpredictable changes and improvements in motor vehicles.

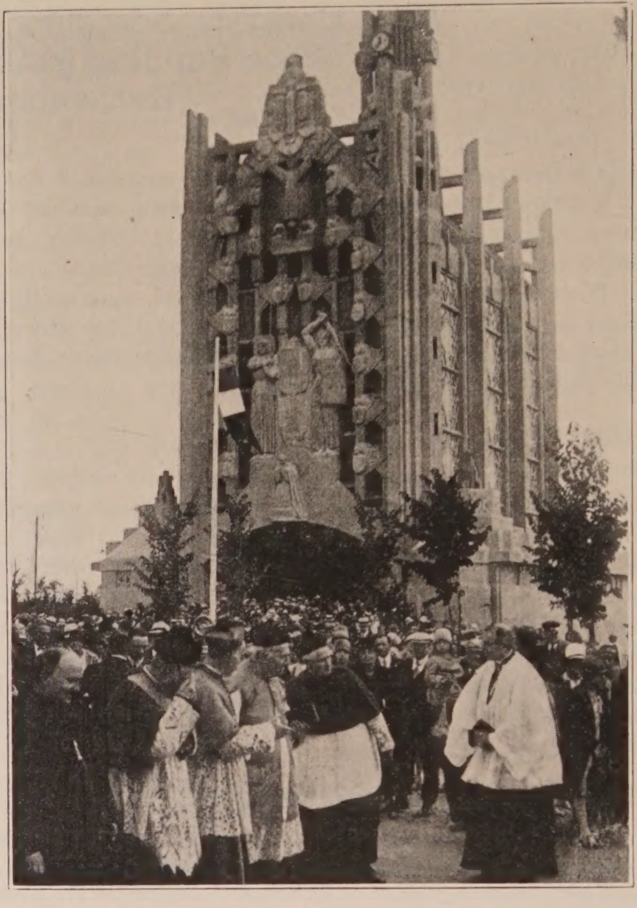
"Many localities are not adequately served with feeder roads that can be traveled at all seasons of the year. These inadequate feeder roads must be surfaced so that the loads hauled on the main highways can be carried over the feeders without reducing the loads or damaging the vehicles."

French Village Boasts Unique Concrete Church

Grenoble, the center of the French cement industry, contains some excellent examples of concrete construction and many of its office, factory and public buildings are built entirely of that material. While many of these buildings are attractively designed, the majority of them are plain and their architects have sought for utility rather than beauty. The Saint Romain Church at Grenoble is a good example of this simple but graceful and attractive architecture.

With the increasing interest in "modern art" in France, concrete has been the medium for a series of architectural experiments that have not only proven satisfactory but have opened a new epoch in architectural decoration. Several well-known French sculptors have been devoting their efforts to the molding and carving of partially set concrete and particularly in the construction of churches have their efforts been successful.

A splendid example of this form of religious architecture, a church erected as a memorial to Franco-Belgian friendship, was recently inaugurated in the Paris suburb of Elizabethville, a small town on the banks of the River Seine. The first impression of the edifice is the appearance of extreme lightness. Everything in the structure, excepting windows and a small amount of iron-work, is of reinforced concrete. Foundations, walls, spire and ornamentation are all in this material and of slight and fragile appearance. Even the altar, pulpit and baptismal fonts were constructed with cement.



French church structure typical of architecture employed in numerous instances

The unique features of the structure are the decorations and statuary. The entire front is occupied by statues and relief work sculptured in the cement by the well-known artist, M. Sarrabezolles. The smaller pieces represent the coats-of-arms of the Belgian provinces and the effigies of the cathedrals of France. The statue over the doorway is that of the late Cardinal Mercer while the upper one is that of Saint Thereze.

The sides of the church are almost entirely of stained glass set in a delicate lacework of concrete of a very fragile aspect.

Maintenance Cost of Concrete Pavement Is Lowest

A recent survey of pavement maintenance costs has been made covering 54,915 miles, E. E. Duffy of the Portland Cement Association states.

The average yearly surface maintenance costs for the various types are shown to be: Bituminous surface-treated macadam, $1,072; macadam, $500; bituminous macadam, $498; gravel, $456; bituminous concrete, $383; brick, $381; and concrete, $121.

EDITORIAL

Cutting Costs Instead of Improvements

EDWARD J. MEHREN, president of the Portland Cement Association, in a letter recently addressed to Robert J. Lund, president of the National Association of Manufacturers, agrees with the thesis that government costs must be reduced; but at the same time he points out the importance of making a clear distinction between wasteful current expenditures and wise capital investment.

"There is grave need," Mr. Mehren said, "for reduction in government costs. Duplicated, overlapping and wasteful functions should be eliminated. It is highly important, however, to distinguish between wasteful current expenditures and wise capital investment. The latter creates employment, is not competitive with private industry, and if truly wise, finds economic justification in the money saved or earned.

"For a number of reasons this is a favorable time to undertake needed public works. The community can eat its cake and have it, too. Bonds of financially stable communities are selling at par or even at a premium. Many other high class municipal bonds are selling at small discounts. On the other hand, construction costs are off materially. The average cost of paved highways is between 20 and 30 per cent under that of 1930. Building costs have dropped as much. Even if bonds must be sold on a 6 per cent basis, the ultimate cost of the work to the public would be a bargain compared with the costs of work for a decade prior to 1929.

"As to the nature of wise public investment, be it noted that American cities are using thousands of miles of wornout pavement, uneconomical to maintain and costly to users. There are 247 cities of more than 1,000 population in the United States which have no sewage collection systems whatever and almost 6,000 which have no disposal plants. These conditions continue in the face of constant protest from state and municipal boards of health.

"Business leaders and public officials have come to see the function of public works in speeding up the business machinery," the letter concluded, "which is added reason for keeping in mind the distinction between current expenditures and capital investment."

Modernizing the Store Front

THE Cast Stone Institute is offering effective assistance to architects and to manufacturers of cast stone in the promotion of modernized store fronts.

It is well known that behind many an old-fashioned front wall of a retail business building stands a sound structural frame that is good for another generation. The Cast Stone Institute believes that the remodeling and modernizing of such retail business fronts will constitute a considerable volume of construction during the next few years.

On the basis of this belief, manufacturers of cast stone are urged to co-operate with architects in the development of this business. In some instances this combination is already in operation, the manufacturer making use of sketches prepared by the architect as a means of gaining the interest of the owner or the tenant, and promoting the use of cast stone for the work.

Patrons of certain lines of retail business are naturally drawn to buildings of attractive and modern appearance. To them the outward appearance is an indication of the character of merchandise displayed within.

With few exceptions, every block in the retail business district of every city, whether large or small, contains examples of cases where business firms that cater to a discriminating trade are quartered in buildings of drab appearance.

Freedom of design with respect to form, color and finish makes cast stone peculiarly adaptable to this type of modernization. Manufacturers and architects may both profit through the cultivation of this field.

Put the Available Funds to Work

IF a community needs a more efficient water supply system, or sewage disposal facilities, or a new bridge, or modern street and highway paving, now is the time to pick up courage and push the project.

Public officials are presented with the three-ply opportunity of taking advantage of low construction costs, providing employment, and aiding in giving force to the business stimulant that is expected from the construction money made available by recent congressional legislation.

If the project can be classed as self-liquidating, and no local funds are available, prompt and vigorous action may obtain the necessary funds from the Reconstruction Finance Corporation. In one large city an important highway bridge left half completed is now to be made a toll bridge project, so that money may be obtained from the R. F. C. to complete the structure. Tolls are to be charged only until the loan is repaid.

Now that funds have been made available, the greatest good will result by putting that money to work at the earliest possible date, on projects that are worthy.

PROGRESS—In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Standard Samples of Cast Stone to Be Distributed

A PRELIMINARY conference of manufacturers of cast stone was held in Washington, D. C., on June 17, for the purpose of considering the proposed commercial standard and purchase specifications covering cast stone (see July issue of CONCRETE, page 12).

The conference was well attended and it accomplished definite results. It was decided that differences in shade and texture and differences in manufacturing methods would necessitate the selection of 14 standard samples. These are indicated in the accompanying table, the letters A, B and C denoting differences in shade and texture.

TABLE OF STANDARD SAMPLES OF CAST STONE

Designation	*Color*	*Finish*
SS-10A	Gray	Smooth
SS-10B	Gray	Smooth
SS-10C	Gray	Smooth
SS-20A	Gray	Bush-hammered
SS-20B	Gray	Bush-hammered
SS-30	Gray	Brushed
SS-40	Gray	Etched
SS-15A	Buff	Smooth
SS-15B	Buff	Smooth
SS-15C	Buff	Smooth
SS-25A	Buff	Bush-hammered
SS-25B	Buff	Bush-hammered
SS-35	Buff	Brushed
SS-45	Buff	Etched

In accordance with the standardization program, small duplicates of the standard samples are to be made available to manufacturers through the Cast Stone Institute, and will probably be ready for distribution about September 1, 1932. Sets of samples are to be prepared by the Institute and placed in various federal, state and municipal construction departments and in private architectural offices for use in selecting and specifying cast stone for particular jobs.

Present plans call for a small sample of the cast stone specified to be furnished to the successful general contractor and another to the building inspector for comparison with the cast stone actually delivered.

It is not expected that any one manufacturer will be able to furnish cast stone to match all proposed standard samples. Each manufacturer is expected to work out his own formulas for matching the standard samples, using his own available materials. In this work the manufacturer is to be furnished with as much information as the Institute has available concerning ingredients, source and size of aggregate. A list of manufacturers throughout the country will be prepared, showing the standard colors and finishes that each can furnish. This list will be distributed to federal, state and municipal construction departments and architects and general contractors to inform them which of the standard cast stones are available in various sections of the country.

The proposed standard sample plan will be tried out for a reasonable period, after which it will be brought to a general conference of manufacturers, distributors and users of cast stone. It is believed that the plan will be widely adopted and will be a powerful aid in getting cast stone used on work where present methods of specifying it do not give the desired results.

Plans for Modern Tenement Block

AN ARCHITECT working in co-operation with the Portland Cement Association has prepared a design for a reinforced concrete tenement to occupy a city block and to accommodate 448 families in 1,627 rooms. The exterior is to be of exposed concrete, simple but architecturally attractive. The building will be fireproof throughout, with interior walls and partitions of concrete, as well as floors and stairways. It is hoped that a design can be produced which will permit an investment return of six per cent on a monthly rental basis of $6.00 per room. Low costs of land and construction will, of course, be necessary in achieving this low rental; but present indications are that the plan is entirely feasible.

The building is a 3-story English basement type of structure, the high basement being occupied largely by apartments.

Architects desiring copies of block plans and elevations should address the general office of the Portland Cement Association, 33 W. Grand Ave., Chicago, Ill.

Masonry Cement Specifications Adopted by A. S. T. M.

APPROVAL was recently given by Committee E-10 on Standards to the publication of the Specifications and Tests for Masonry Cement (C 91-32 T) as a tentative standard of the American Society for Testing Materials. The specifications were submitted for consideration by Committee C-1 on Cement. It is thought that the publication of this tentative standard will accelerate interest in improving the methods of testing masonry cement. The need for standard specifications has been evident for some time due to the many types of cement on the market.

Copies may be obtained by addressing the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Penna.

Engineering Index Service of A. S. M. E.

THE Engineering Index Service, a division of the American Society of Mechanical Engineers organized in 1927, announces that it is now supplying reviews of engineering articles in more than 2,000 current technical publications, coming from 40 different countries and printed in 20 different languages.

Stability of Concrete Masonry Shown in Tests of Wall Piers

Load Tests at Ohio State University Confirm Results of Wall Stability Tests at University of Illinois

IN many respects the load tests of full-size wall piers of hollow concrete masonry construction conducted at Ohio State University and reported in a recent bulletin[1] have confirmed the results of the wall stability tests[2] made in 1931 at the University of Illinois.

Test Results in Close Agreement

For example, in the Illinois tests the compressive strength of the walls averaged 53 per cent of the strength of the individual units. In the Ohio tests this average was 51 per cent.

In the Illinois tests the compressive strengths of the large walls of all types ranged from 335 to 850 lb. per sq. in. In the Ohio tests, where all loads were applied eccentrically, the compressive strength of the two piers built of gravel concrete units was 572 and 767 lb. per sq. in., respectively. The three piers of haydite concrete units tested 425, 516 and 565 lb. per sq. in., and the two of cinder concrete units tested 247 and 386 lb. per sq. in.

Both series of tests indicated ample factors of safety in the types of construction examined.

Full-Size Wall Piers

The tests at Ohio State University, which were made in co-operation with the Common Brick Manufacturers' Association of America, were made on full-size wall pilasters and adjoining wall sections set 30 ft. apart, with a 16-in. steel beam spanning the distance between them. The steel beams were supported on bearing plates. As the beams deflected, the eccentricity of the applied load increased correspondingly.

Dimensions of Piers

Two of the wall piers were built of cinder concrete units, two of gravel concrete units, and three of haydite concrete units. Two sizes of piers were built. One size had 8-in. walls, 2 blocks or 32 in. long, with a 4- by 16-in. pilaster projection, making a 12- by 16-in. pilaster with the wall thickness included. The other size had 12-in. walls 32 in. long, with a 4- by 16-in. pilaster projection, making the entire pilaster 16 in. square. The smaller piers were 10 ft. high to the bearing plate and the larger were 14 ft.

One specimen of each size was built of each of the three kinds of units. One other large pier was built of haydite units in which special units 12 by 16 in. in size were used. This pier is referred to as No. 7 in the tables and text of the full report, a 6- by 9-in. bulletin of 35 pages.

The bearing plates were 12 by 16 by ½ in. in size on the smaller piers and 16 by 16 by ½ in. on the larger.

Conclusions from the Tests

The results of these tests threw considerable light on the behavior, both as to ultimate strength and elastic properties, of three common types of hollow portland cement concrete building block units in building walls and pilasters when loaded by means of beams, girders or trusses which deflect to the full building code limit of one in 360. The conclusions are as follows:

1. The ultimate strength of the masonry is about one-half of that of the unit. The individual percentages are as follows: Cinder block, 63 and 41 per cent. Gravel block, 44 and 59 per cent. Haydite block, 56, 51 and 45 per cent. The average is 51 per cent.
2. The maximum unit stresses under the bearing plate at working load and full beam deflection are about four times the average working stress over the entire plate. The individual ratios for points on the piers where the unit stresses are somewhat less than the maximum are as follows: Cinder block, 2.83 and 6.12. Gravel block, 3.26 and 3.23. Haydite block, 3.30, 3.32 and 4.01. The average is 3.73.
3. The factors of safety based upon the ultimate unit strengths and the allowable working stress of 90 lb. per sq. in. are as follows: Cinder block, 4.29 and 2.74, averaging 3.51. Gravel block, 6.35 and 8.52, averaging 7.43. Haydite block, 6.28, 5.73 and 4.71, averaging 5.57.
4. A 1:3 portland cement mortar tempered with 10 per cent of hydrated lime is sufficiently strong for portland cement concrete block masonry.
5. The lateral deflections at working loads are not of serious consequence. The maximum was 0.038 in. in 120 in. or 0.114 of an inch in 360 in., which is only a little more than one-tenth of the 1:360 ratio allowable in beams. The average was 0.075 in. in 360 in. The lateral deflections above working loads did not increase in proportion to that below. The maximum at 80 per cent of the working load was 0.369 in. in 360 in. The lateral deflections were independent of the moduli of elasticity.
6. The internal bending due to the eccentric loadings extends down into the piers for distances proportional to the moduli of elasticity. In other words, those piers that had the lowest moduli of elasticity absorbed the bending due to the eccentric loadings in the shortest distance from the load.
7. Special shapes such as those used in pier No. 7 are inferior to the standard block shape in producing pier strength.

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[1] Bulletin No. 60, Engineering Experiment Station, Ohio State University, Columbus, Ohio, entitled "Strength of Concrete Block Pilasters Under Varied Eccentric Loading."

[2] See August (1931) issue of CONCRETE, pages 15-16.

8. The wing walls (wall sections adjacent to pilasters) at working loads may be depended upon to take up their share of the bending throughout the entire length of the pier and 80 per cent of their share of the compression load at the mid-height. The larger piers took a larger proportion of the load at mid-height than the smaller ones. It takes about 7 ft. of height to bring the wing walls into full service.

Exception may be taken to the wording of conclusion No. 4, to the effect that a 1:3 portland cement mortar tempered with 10 per cent of hydrated lime is "sufficiently strong" for concrete block masonry. As a matter of fact, Table 1, on page 10 of the full report, shows that the compressive strength of the mortar was fully twice the strength of the individual concrete units, and fully four times the strength of the piers. In consequence, the investigators might well have considered that their test results bear out the conclusions of other investigators, namely, that a 1:1:6 cement-lime mortar is amply strong for concrete masonry construction.

Acknowledgments

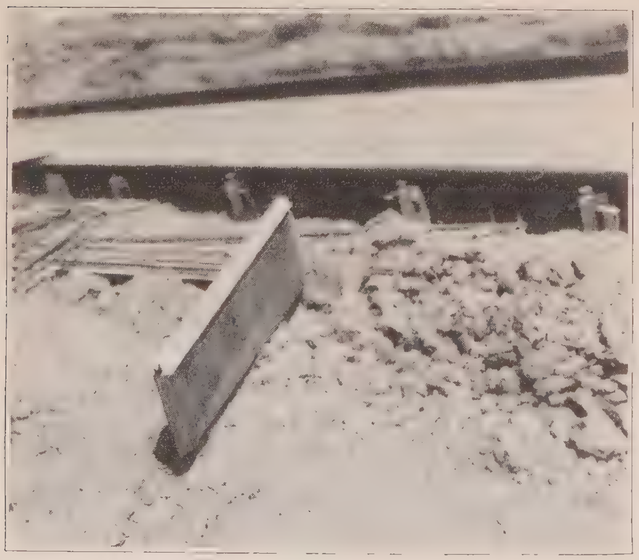
These tests were conducted by J. R. Shank, research professor, and H. D. Foster, research engineer, Ohio State University, under the direction of Dean E. A. Hitchcock, director of the Engineering Experiment Station.

Installing New Air Cushion Joint in Middle West

How Air Cushion All-Metal Expansion Joint Is Used —Of Sheet Iron Construction Bent to Shape of "U"

The first extensive use in the Middle West of the air cushion all-metal expansion joint is on a state highway job near Des Moines, Iowa. As this joint is new the methods developed for its installation may be of interest to engineers and contractors.

The air cushion joint is a strip of sheet iron bent to the shape of a long narrow "U" with the open end of the "U" covered by a metal cap bent to a bellows section. The sides of the "U" are ⅝ in. apart. The closed end forms the bottom of the joint and the bellows end the top. The bellows section has ears which anchor it into the concrete and is made of a highly rust-resistant iron and copper alloy. As the concrete expands and the joint closes the bellows cap collapses; as the joint opens, the cap, being anchored to the concrete, opens up, keeping the joint always closed to the entrance of sand and dirt or other foreign matter. Holes are punched through the metal sides of the joint at the proper intervals to receive slip dowels.



The air cushion joint is a piece of sheet iron bent to the shape of a long and narrow "U," with the open end of the "U" capped by another piece of sheet metal bent to a bellows section

The joint is in short sections with male and female connection at either end. The end sections are trapezoidal to form the thickened edge. It is being placed at 10 ft. intervals on a paving job 16.4 miles long. The joint is made by the Truscon Steel Co.

The template rests on the side forms and has convenient handles at each end. At intervals along the template there are attached to it steel fingers, hooked on the end to hold the joint to the bottom.

Template and joint are set on the subgrade, the template resting on the side forms, and stakes are driven to hold them in place while concrete is deposited

The joint is placed on the bottom edge of the template by two workmen working outside the forms. When the location for the joint is reached the template and attached joint are lifted into position. Three stakes are driven on each side of the template to hold it in place while concrete is placed about it. A detachable cap is placed over the bellows section to keep mortar from getting into it and make it easy to remove concrete from above the joint.

When concrete has been deposited on both sides of the joint, stakes and template are removed and the concrete is finished right over the joint. After finishing is completed the temporary cap is pulled off, removing concrete above the joint material and the joint is edged. Later, when the concrete has hardened, the space above the joint metal is filled with hot bituminous material.

Advocates Trial Mixtures for Concrete Pipe and Block

Discusses Gleeson Method of Grading Aggregates—Thinks Percolation Controlled by Quantity of Excess Water Rather Than Voids in Aggregate

By GEO. L. REED
Regional Structural Engineer, Portland Cement Association, Atlanta, Georgia

AFTER giving careful study to the excellent article by George W. Gleeson, appearing in the June (1932) issue of CONCRETE, and noting especially that comment and criticism are invited, I am offering the following discussion, hoping that it will be found constructive and of some value in the solution of this most interesting problem of aggregate grading.

I am especially glad to see such a work in print, as there is a serious dearth of material regarding design of mixes for mechanically compacted concrete products. It has been part of my work for the last five years to design such mixes for several plants, both for pipe and building units, and while the method I have used is very much rule-of-thumb, it has served excellently so far. At the end of this discussion I will describe this method briefly.

Should Hold Uncombined Water to Minimum

The grading of aggregates which Gleeson recommends is selected on the assumption that it is desirable to produce a combined aggregate of minimum voids. In fact, he states that the variation of void space is the true measure of resistance to percolation. This premise and this statement I find rather unsupported in his paper and other literature on concrete.

We have very little information on the relation between the void space in combined aggregate and the voids in hardened concrete, if any relation exists. To consider for a moment workable concrete (with sufficient water to make the mix plastic, too wet, of course, for mechanically compacted concrete) when concrete is placed in a container or form, if we neglect the negligible amount of entrapped air there are no voids whatever in the concrete; the entire space within the container being filled either with aggregate, cement or water. After the concrete has hardened the only voids are those left by the evaporation of uncombined water.

The problem of producing dense (with respect to voids rather than unit weight) concrete, resistant to percolation, becomes that of reducing to a minimum the amount of uncombined water or the excess water in the concrete at the time of placing.

Main Purpose of Aggregate Grading

Aggregate grading becomes important, not because different grades have different densities (percentages of voids), but because different gradings have varying effects on the workability of the mix and the amount of water required to produce any given degree of plasticity. Thus, an ideal grading, considering percolation, is one which produces the necessary workability with the least excess water, since it is the excess water which, as the concrete hardens, leaves the only voids through which percolation can take place.

Of course, resistance to percolation is affected by other things, to-wit: Curing and cement content, both of which affect the amount of uncombined water.

While aggregate grading which has the least percentage of voids may be that requiring the least water for a given workability, this is not necessarily or generally the case. (See "Studies of Workability of Concrete," by T. C. Powers, February (1932) *Journal* of the American Concrete Institute.)

The above discussion is entirely with reference to plastic mixes of concrete and the principles outlined may not apply to mechanically compacted concrete. It is possible in the latter that void spaces do exist in freshly made concrete; and in hardened concrete there may be voids other than the spaces left by the uncombined water. Such space would probably be indicated by absorption tests.

Trial Method Employed

The method which has been used with some success in several instances in the South for design of pipe and products mixes has been to design a suitable wet plastic concrete by trial, selecting the aggregate combination producing the most economical mix, generally a 5-gallon mix for pipe and a 6½- or 7-gal. mix for products. With this combination of aggregates, the water was reduced as necessary for the particular machine involved and a series run with varying cement contents. From the test on this series it is possible to select a cement content producing block or pipe to meet any specification.

◆ PERSONAL ◆

George K. Burgess, director of the U. S. Bureau of Standards, Washington, D. C., passed away suddenly on July 2. Death was due to a cerebral hemorrhage.

Dr. Burgess first joined the bureau in 1903, as physicist. He subsequently became head of the division of metallurgy, and director. He was a member of numerous organizations, including the A. S. T. M. and the National Research Council.

Test Procedure for Control of Ready-Mixed Concrete

—Value of Independent Inspection and Certification
—Much Variation in Specifications to Be Met
—Well Designed Plant Simplifies Control

ONE of the principal reasons why ready-mixed concrete has attained its important position in the concrete field in the short period of less than a decade is the demand by the architect, engineer and contractor for a high quality controlled product. Proper control is economically possible only on the larger concrete jobs and for ready-mixed concrete operation. Control in the case of the ready-mixed concrete plant involves more than on the usual large construction contract. The ready-mixed concrete operator must produce concrete uniform in quality from load to load, and he must also produce a definite and generally uniform quantity from load to load. The quality desired may be defined by any combination of a number of factors, including compressive strength, modulus of rupture, slump, workability, size of aggregate, temperature, proportions, cement content, and water-cement ratio. The combination of qualities to which particular attention is required in a given case is defined generally by the specifications under which the concrete is purchased. The control of the quantity from batch to batch or for each load is essential because concrete is sold by the cubic yard.

Very few small ready-mixed concrete plants have more than an occasional check on their operations; and the larger plants, in a number of cases, operate without sufficient technical supervision. The matter is of importance because the concrete produced under these conditions is frequently disappointing to contractors, engineers and architects, who were expecting something unusual in quality.

Control Is Not a Simple Matter

In this paper will be outlined what is considered essential for control of quality of concrete so as to get uniformity between batches and from hour to hour and day to day. No pretense is made that this entire procedure has been followed through satisfactorily by any organization known to the author; but examples are given from practice where certain parts have been put into effect.

The control of the quality of concrete is not a simple operation under the conditions of varying specification requirements, sometimes from batch to batch, particularly if the aggregates are variable in quality and the plant poorly designed. Quality control, for success without excess cost, must start with the materials at their source and with the design of the plant and equipment. The aggregates must be produced to definite specification tolerances and so transported and handled that when delivered to the storage bins of the concrete proportioning plant the grading has not been appreciably affected.

If the materials are uniform in quality and the plant well designed and equipped, the problem of control of quality and quantity of the concrete is not difficult; but in any case, the procedure is the same.

The determination of the quantity of yield is a simple matter and computations based on the absolute volumes of the constituent materials check closely with the measured volumes.

The Control Procedure

The procedure necessary to control the concrete so as to give a desired cement content, strength or some other quality is generally well known. The cement content can be computed from the known characteristics of the aggregates by the absolute volume method, the strength can be controlled by keeping the water-cement ratio constant as long as the mixture is workable, the consistency and workability can be maintained constant by adjustment of the proportions. The work should be done by a concrete control engineer, working in a laboratory in the plant itself. Tests should be made of the aggregates three times a day, or whenever a change is noted. The complete mechanical analysis, which includes grading, voids, weight per cubic foot, and specific gravity, will give all the data required except for the moisture content, which should also be determined at the same time. Preliminary design of mixtures should be made on the basis of the fineness modulus method, surface area, or the mortar voids, and adjusted on the findings from trial batches. Data properly collected from the actual plant operations will, after a full year's operation, provide a better basis for actual design of mixtures than any other. The control tests that will provide this information should include compression tests, modulus of rupture tests, consistency determinations, effect of time of haul on consistency, and strength and temperature change in transportation to the job. The data must show the effect of different cements commonly called for at the particular plant and of the types of agitator or mixer equipment used.

Age-Strength Relation

Such special investigations may well include such related questions as the gain in strength with age and the effect of admixtures and colors. Age-strength tests should start with one day and run to ages as high as one year. Longer periods of test are of little value, as conditions change too rapidly. The early strengths related to the later strengths are of value in giving an early indication of deviations. The later age tests give an idea of the durability of the concrete. It is advisable to look with suspicion upon a cement that shows retrogression in compres-

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Condensed from paper presented by Miles N. Clair, vice-president, the Thompson & Lichtner Co., Inc., Boston, Mass., before the annual meeting of the National Ready-Mixed Concrete Association, January 25-26, 1932.

sion tests, and avoid its use. Long time tests are the only direct means of checking up on this characteristic.

Checking Up on Admixtures and Colors

Tests of admixtures and color are desirable so as to avoid having to handle a large number and to avoid the use of deleterious materials. No matter what the architect or engineer specifies, he is likely to blame any poor result on the concrete producer.

The Mixer Operator's Part

Any discussion of control is incomplete without indicating the importance of the mixer operation. If the plant is semi-automatic, the operator has less effect on the quality control; but in the usual plant his interest in accurate weighing and in noting changes in materials and the concrete, for correction by the control engineer, determines largely the amount of variation that occurs in the concrete. The mixer operator should be a practical concrete man with a real knowledge of the problems of its use and with an appreciation of the effect of various factors on its quality. A careless or inefficient operator is readily detected by records of the strengths, consistencies and wet analyses of the concrete.

Value of Independent Inspection

All of the control tests so far described may be carried out at the concrete proportioning plant by an employee of the organization; but it is generally desirable, for a number of reasons, to have a check made by an outside or certifying organization. The routine check on proportions and strengths by an independent inspection organization has the effect of keeping the men "in line" and it provides data that may be utilized for sales promotion work. Such inspection should be made at least every two days of operation, without notice, and checks of the quantities entering the batch and the resulting concrete.

It may seem that the control program outlined is too large for a usual size plant; but in the writer's opinion this is the minimum necessary for a plant of 500 cu. yd. per day and larger. The work can be done by a control engineer with the assistance of an intelligent laborer whose spare time can be utilized for other work around the plant. The smaller plants may dispense with the full-time concrete control engineer, but essentially the same data must be obtained for proper control. The concrete mixer operator or the proportioning plant operator in this case must be guided by charts of quantities giving limits between which to work under definitely specified conditions.

Some Questions to Be Answered

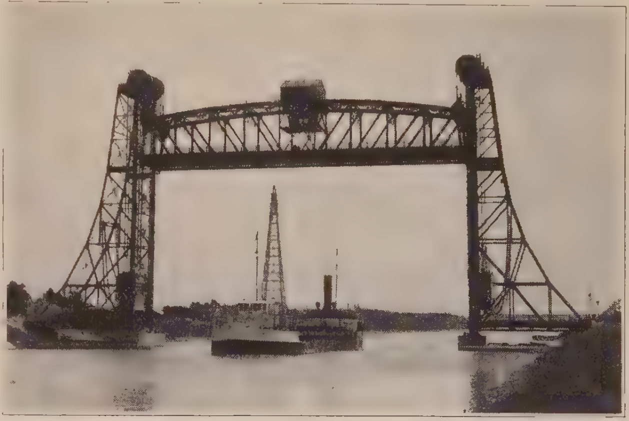
If the control tests and special investigations suggested are carried through and properly studied and tabulated, the concrete will not only be of uniform quality and quantity from hour to hour and from day to day, but the plant operator will have the data to answer questions necessary for operation and sales, such as "What strength consistency must you have at the plant to have a given consistency at the job?" "What temperature must the concrete or the materials have at the plant to have a concrete of a certain temperature at the job for a given haul?" "What is the most economical mixture to produce concrete of a specified modulus of rupture?" "How uniform is the concrete throughout the batch in the agitator truck or the mixer truck under given conditions?" "How much may the plant mixing time be reduced when different types of agitator trucks are used?" "What will be the material cost for a certain mixture?"

The answers to many of these questions are different for each plant. The cost of control in either case should not exceed 10 cents per cu. yd. It will be well repaid by the satisfaction of customers due to the increased quality.

Lift Bridges Over Welland Canal Have Light Concrete Decks

Fifteen lift bridges over the Welland Canal, connecting Lake Erie and Lake Ontario between Port Colborne and St. Catharines, Ontario, have roadway and sidewalk deck slabs built of reinforced concrete in which haydite was employed as the aggregate.

The primary purpose in using this material was that of keeping down the dead-weight. The power required to operate this vertical life type of bridge is in direct proportion to the weight of the movable part of the bridge. In consequence, the reduced dead-weight obtained by the use of light-weight concrete not only reduced the weight of the steel structure, but it has a permanently favorable effect on the operating cost.



One of fifteen lift bridges over Welland Canal which have light-weight concrete roadway and sidewalk decks

The illustration shows a view of one of the lift bridges, which were designed by the Canadian Department of Railways and Canals.

Concrete Wartime Ships to Be Sunk as Breakwater

Six concrete ships, built by the U. S. Shipping Board during the last year of the world war, are to be towed from New Orleans to the mouth of the Grijalva river in Mexico and sunk as a breakwater. Only one was ever used by the government.

For a number of years, three of the vessels, anchored near the west bank of the river at New Orleans, have been used as stationary fuel oil tanks by a barge line. The other three ships have been tied up at Chalmette, below the city.

The ships were built at a cost of approximately $1,000,000 each. They are 300 ft. long and have a 35-ft. beam. They were not suitable for commercial operation because they carried 12 per cent less cargo than steel ships of the same tonnage.

Details of Field Inspection of Concrete Construction

Duties of Inspector Stated in Logical Order—Must Give Special Attention to Steel—Experience and Constant Alertness Needed

By D. B. RUSH
Manager, Cement and Concrete Dept., Robert W. Hunt Co., Chicago, Ill.

THE complexities of field inspection or supervision of a modern concrete building are such as to require the constant attendance of one or more trained experts in reinforced concrete work.

In the last few years, our organization has handled the field supervision on more than 200 concrete structures, ranging from 26-story reinforced concrete hotel buildings to private residences. Quite naturally, the details of each type of construction are entirely different, and it would be impossible to get any one man who was sufficiently familiar with all types of concrete construction to be classed as an expert on all of them. There are four general classes into which such construction falls, and it is possible, and we have proved it practical, to have men trained in each one of these particular lines of work.

The inspector arrives on the job just as the excavation work is being completed and the forms are being set. He reports his presence to the superintendent and then starts work. If he has not already been provided with specifications he obtains them at the site, as well as a complete set of drawings. Most specifications are identical in their general provisions, but sometimes there are changes that are important.

Keeping the Cement Dry

The material will now appear on the scene. Cement should be stored in a dry, clean shed, and it is up to the inspector to see that this is done. The contractor is often tempted to leave the bags lying on the ground with either no protection or just a canvas covering. If the cement has been tested in the inspection engineers' laboratory the results of these tests are in the hands of the inspector and he knows whether or not it is acceptable. The bags will have been tagged by the inspector who took the samples of cement. These identify the cement and are kept by the inspector for record.

As soon as the fine and coarse aggregate arrive the inspector begins making his tests to determine its suitability; if it fails in any way to satisfy him, rejection is made and the material is sent back. Besides the tests, such as colorimetric, silt, shale and grading, the percentage of water and bulkage is determined. These last two tests and the fineness moduli give him values with which to design his mix.

Arrangements for Correct Proportioning

After designing the mix for the specified strength it is necessary to determine what methods are to be used in measuring the materials before they are put into the mixer. Generally the mixer will have some sort of arrangement whereby the water is automatically set at a certain amount. This should be tested to see that it is working correctly and then set at the predetermined amount. The cement is delivered in cubic foot bags, so no trouble is encountered in that respect. The aggregate may be stored in hoppers which automatically give forth the required amount, and in such case it should be tested and set. Generally, however, the aggregate is stored on the ground and shoveled into barrows to be wheeled to the mixer and dumped. In such a case the cubic foot contents of the barrows should be determined and the men trained to put in just the right amount of material. Not only is training required, but constant watching is necessary to see that this particular is complied with.

With the mix designed and the provisions made to insure proper proportions, the inspector now examines the forms. They should be, in every respect, as shown on the drawings, free from holes and cracks, and clean. Before the footings are concreted, water should be pumped out, leaving a smooth bottom free from loose dirt and openings.

Checking Up on Steel Reinforcement

The reinforcing bars are next on the inspector's list. If these have been previously inspected at the shop they will be tagged for identification. The inspector takes these tags and compares them with his report showing the tests which have been made. If the bars are satisfactory they are accepted. If bending is done at the site, the inspector should compare such work with his drawings to assure himself that no errors are committed.

When the reinforcing steel is placed in the forms the inspector must see that the job has been done correctly, that the right size bars are placed in the position called for in the plans. This last provision is important, for one steel foreman boasted that until inspectors were put on the job he saved 40 tons of steel in every large building that he worked on.

When Many Eyes Are Needed

With forms set and reinforcement placed, the concrete is ready to be deposited. It is at this point that the inspector needs several pairs of eyes instead of one. He must watch the materials as they are loaded into the mixer, to see that correct proportions are used; he must time the mixer to see that the required time is given (a point seldom given any attention by the contractor's superintendent, whose sole aim is to get done as soon as possible); he must watch the placing of concrete to see that the material is not only dumped correctly but that it is spaded adequately, and that corners are filled in and concrete placed around and in between the reinforcing bars; he must make frequent slump tests to check his design, and he must make cylinders and store them properly. The forms must be clean and must be watered prior to placing concrete. He must also see that new work is properly connected to old, and that the contractors' men do not destroy any of the work through carelessness.

Protection of green concrete is another of the inspector's duties. He must see that forms are not removed too soon and that when they are removed the naked concrete will be kept moist and protected from intense heat, cold or wind.

Importance of Competent Inspection

The importance of the inspector and the need for a competent man is easily realized when his duties are known. The job is not an easy one. Because of the technical training required and the amount of work required of them, and because of the vast amount of detail outside of concreting which the architect's superintendent must take care of, the best plan to follow is to employ a reputable testing engineer. There are a few whose experience in this field, from the inception of concrete construction, qualifies them as experts. They are prepared to send out a trained man of good judgment, character and experience to supervise the concrete construction.

The rapid rise to universal popularity of concrete structures has made it imperative to adopt rigid inspection procedures to insure the success of the buildings. The failures that are attributed to faulty concrete work are eloquent testimonials to the need for complete, competent inspection, and to the lack of sufficient supervision now being given by municipal inspectors. In this connection Edward C. Kerth, former commissioner of buildings of Evansville, Indiana, published the following statement:

"There can be no doubt of the superiority of such (independent) inspection over our present limited and inadequate system, which is everywhere undermanned and underfinanced. By the application of inspection as a private enterprise at the owners' expense we are not attempting a radical reform in building methods, nor will we lessen the work of building departments. But we will provide something that the owner is often paying for and seldom receives—the constant attention of his personal representative who can vouch for the structural safety and proper construction of the project."

Contractor Builds Much Concrete Work Around Picnic Grounds

By A. L. SMITH

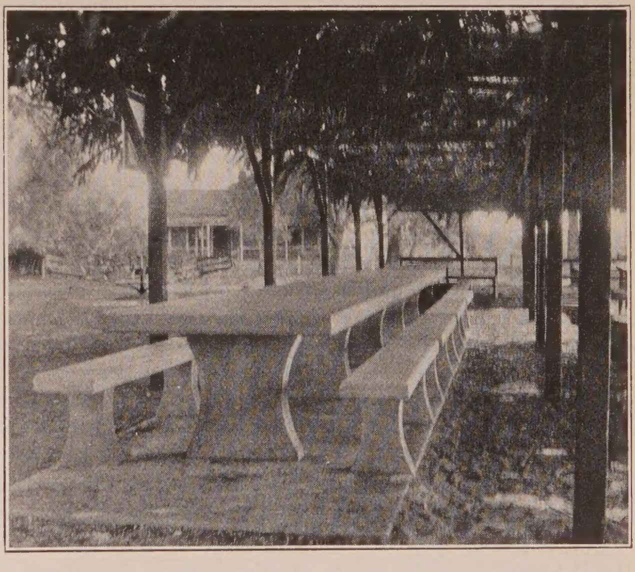
H. D. Bourey, a concrete contractor in Escondido, California, has done a great deal toward cultivating a market for concrete improvements around parks and picnic grounds. Examples of his work are the picnic table and benches which he built in Grape Day Park, San Diego. The illustration shows the table and benches.

The table is 25 feet long, 3 feet wide, and 3 feet high. The table top consists of a concrete slab 4 inches thick and rests on five reinforced concrete supports. There are four reinforced concrete benches on either side of the table. Each bench consists of a concrete slab 5 feet 6 inches long and 1 foot wide, with concrete supports at each end.

Both the table and the benches are placed on a 4-inch concrete base or floor, laid on well-tamped earth. When this concrete base was placed, dowel and reinforcing rods were set in the base slab for attachment to the supports for the table and benches. The forms for the supports and the table and the bench tops were next built and concrete placed for all in one operation. Reinforcement consisted of ½-inch bars.

This picnic table and the benches were built for the "20-30 Club" of Escondido, which is composed of young men between the ages of 20 and 30 years. An hour-glass, the emblem of the "20-30 Club," is inlaid with colored concrete tile in the center of the table.

The city council of Escondido agrees that all future improvements to the picnic tables in this park will be similar to those built by Mr. Bourey. Incidentally, he is contacting other service organizations to get them to follow the lead of the "20-30 Club" and replace other wooden structures in the park with permanent ones of concrete, making Escondido's Grape Day Park a modern and up-to-date recreational center.



Concrete table and benches in Grape Day Park, Escondido, Calif.

Other concrete improvements that have recently been built in Grape Day Park are an outdoor stove[1] and oven and a reinforced concrete swimming pool, the latter having been built by money raised through public subscription.

Division of Road Money in Relief Act

The highway funds provided in the total of $136,000,000 in the Emergency Relief and Construction Act passed by Congress are: $120,000,000 for emergency construction on the federal aid highway system; $5,000,000 for national forest highways; $5,000,000 for improvements of national forests; $3,000,000 for national park roads, and $2,000,000 for roads through public lands.

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[1] For details of a concrete camp stove, see December, 1930, issue of CONCRETE, page 31.

HOW TO DO IT

✦ Questions and Answers ✦
Consultation and Comment

A department devoted to the solution of problems encountered in concrete work. Readers are welcome to add to or improve upon the suggestions printed and to submit their views for possible publication.

Proportioning Aggregates for Concrete Pipe

What are the proportions and sizes of aggregate most commonly employed in the manufacture of concrete pipe?—R. A. W., Marshall, Indiana.

Many pipe manufacturers use mixtures of 1 part of cement with 3 to 4 parts of durable sand, washed and well graded in sizes up to 3/8 in. Or, when the finer and coarser materials are separated, a 1:1½:2½ mixture is often used. The fine material should be a fine sand or other fine aggregate, while the coarse material may range from 3/8 in. down to 1/8 in.

Whatever may be the aggregates that are commercially available in your locality, only carefully conducted analyses and experiments will determine the best proportions to use. Tests can be made to the best advantage at university or commercial testing laboratories.

For a detailed study of aggregates for concrete pipe, you are referred to an article in the June (1932) issue of CONCRETE, pages 7 to 11, by George W. Gleeson. He recommends what he calls intermittent grading, defined as that in which there is a distinct gap between the particle sizes of the finer and the coarser material. For a mixture of two sizes of aggregate he recommends a fine aggregate that, when screened, contains a high percentage of material lying on the No. 48 and No. 100 sieves, and as little as possible on the No. 14 and No. 28 sieves. These latter sizes, he finds, increase the void space and induce harshness.

For the coarser aggregate Gleeson recommends sizes from the maximum down to coarse sand, but with little or no material on the No. 14 and No. 28 sieves. For small concrete pipe (up to 15 or 18 in. in diameter) he employs a coarse aggregate with a maximum size not exceeding 3/8 in. In larger sizes of pipe, correspondingly larger particles of coarse aggregate may be used.

Concerning actual proportions between cement, water, fine aggregate and coarse aggregate, these can be determined only from the analyses of the aggregates to be employed, and by experiment.

Colors for Concrete and Mortar

What kinds of colors are suitable for use in coloring concrete and cement mortar, and what amount of coloring material should be employed?—H. J. M., Chippewa Falls, Wis.

As a general rule, mineral colors should be used for coloring concrete, cement mortar and concrete products. The quantities of mineral colors to be mixed with the portland cement for obtaining certain color effects will be found in a table on page 18 of the January (1932) issue of CONCRETE.

In the formula just mentioned the proportions are on the weight basis. It is necessary always to mix the colors thoroughly with the cement, both in a perfectly dry condition, before the water and the aggregates are added. Unless the colors and the cement are mixed beforehand, the finished product is likely to be streaky.

Names of manufacturers who supply mineral colors will be found in the advertising index of CONCRETE.

Effect of Sugar on Mortar Known 300 Years Ago

News items appearing during recent months in news papers and trade and technical publications have told of the harmful effect of sugar when mixed with portland cement concrete or mortar, and its beneficial effect on lime mortar.

It now develops that these facts were known more than 300 years ago, as indicated in the following letter to CONCRETE *from Roy L. Clark, architectural engineer, Marsh Engineering Company, Des Moines, Iowa:*

The various news items recently appearing in regard to the effect of adding sugar to lime mortar and portland cement mortar, bring to mind a treatise on the subject which I read while doing research work in various architectural and engineering subjects in the Boston Public Library during 1928 and 1929.

The most complete treatise on mortars and plasters, as used in ornamental work, was given in a volume by Miller, and designated in the Boston Public Library as "Plastering"—by Miller—4091-78.

This volume was produced by the author with the cooperation of the last member of a line of craftsmen, who for generations did the ornamental plastering in the governmental buildings for the British government during the time when this type of interior decoration was in its zenith. The volume is more than 300 years old, and I was informed that there are only two copies in the United States, the other one being in the New York City Library. The author states the following concerning sugar in lime mortar: "Plasters are strengthened by adding 3 to 4 per cent of sugar. Water containing sugar has the property of holding more of the lime in solution.

"Dr. Compton discovered that it is impossible to dissolve more than one-half of a grain of lime per ounce of water. But by adding two parts of sugar to one part of lime, the solution contains about fourteen and one-half times more lime.

"Beet root sugar is not good for lime or cement.

"In the plaster in the Berlin Museum of Natural History, one part of lime, three of sand, and two per cent of sugar was used. Herzfeld, the plasterer, states that good molasses will yield as good results as sugar."

‹ ORGANIZATIONS ›

American Association of State Highway Officials; W. C. Markham, Executive Secretary, 1222-24 National Press Building, Washington, D. C.

American Concrete Institute; Harvey Whipple, Secretary, 641 New Center Building, Detroit, Mich. Twenty-ninth annual convention, Feb. 20-23, Chicago, Ill.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

American Road Builders' Association; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 West Thirty-ninth St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, 1315 Spruce St., Philadelphia, Pa.

Associated General Contractors of America; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

Building Officials Conference of America; Col. John W. Oehmann, Secretary, 1253 Lawrence St., N. E., Washington, D. C.

Cast Stone Institute; L. A. Falco, Secretary, Chapel St. and Blatchley Ave., New Haven, Conn.

Cement Institute; Luther G. McConnell, General Manager, 11 East 44th St., New York City.

Concrete Masonry Association; Jack Franklin, Secretary, 7071 Plankinton Bldg., Milwaukee, Wis.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, 333 North Michigan Ave., Chicago.

Engineering Institute of Canada; 2050 Mansfield St., Montreal, Quebec.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

National Board of Fire Underwriters; W. E. Mallalieu, General Manager, 85 John St., New York City.

National Concrete Burial Vault Association; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.

National Crushed Stone Association; J. R. Boyd, Secretary, 1735 14th Street, N. W., Washington, D. C.

National Engineering Inspection Association; B. H. Witherspoon, Secretary, P. O. Box 1115, Pittsburgh, Pa.

National Fire Protection Association; Franklin H. Wentworth, Secretary, 40 Central St., Boston, Mass.

National Lime Association; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

National Ready-Mixed Concrete Association; V. P. Ahearn, Secretary, 545 Munsey Building, Washington, D. C.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 937 Leader Bldg., Cleveland, Ohio.

National Terrazzo and Mosaic Association; U. F. Durner, Secretary, 815 West St. Paul Ave., Milwaukee, Wis.

Northwest Concrete Products Association; W. P. Hews, Secretary-Treasurer, Yakima, Wash.

Portland Cement Association; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Rail Steel Bar Association; H. P. Bigler, Engineering Secretary; Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

Wire Reinforcement Institute; R. D. Bradbury, Director, National Press Bldg., Washington, D. C.

Wisconsin Concrete Products Association; Jack Franklin, Secretary-Treasurer, 425 East Water St., Milwaukee, Wis.

New Books and Pamphlets

Facts About Concrete Masonry

Facts About Concrete Masonry. Published by the Concrete Masonry Association, 7071 Plankinton Building, Milwaukee, Wis. Heavy flexible paper cover, 48 pages, 8½ by 11 in.; many halftone illustrations and line drawings.

The contents of this book are of exceptional value to architects and specification writers, for under this one cover they will have essential information such as nationally accepted standard specifications, the cream of the supporting test data back of such specifications, and a number of construction details showing the proper uses of concrete masonry units in walls and pilasters.

The book will likewise be welcomed by manufacturers of concrete building units, who will find it an excellent piece of promotional literature.

In addition to its value as a textbook on concrete masonry, this new publication contains the complete specifications covering this product, as issued by the American Society for Testing Materials and the Underwriters' Laboratories, and abstracts from other leading specifications. A reference index contains a list of 20 bulletins, specifications, papers and test reports on concrete masonry and other masonry materials.

The attractive appearance of this book is a distinct credit to the concrete masonry industry.

New Book for the Concrete Contractor

How to Avoid Faulty Concrete in Small Structures. Published as Bulletin No. 27, by the Engineering Extension Department of Purdue University, Lafayette, Indiana. Paper cover, 154 pages, 6 by 9 in. Many halftone illustrations. Price 50 cents to non-residents of Indiana; no charge to residents of state.

This bulletin, which was written by J. W. Kelly, concrete specialist, under the direction of W. A. Knapp, professor in charge of engineering extension, may well be described as a textbook for the concrete contractor. In language that is readily followed the book describes and illustrates in detail the proportioning, mixing, placing and curing of concrete, as well as many other details of this form of construction work.

The wide scope of the information contained in the book may be visualized from the chapter headings, which include subject-matter such as buying and handling the materials, aggregate sizes and gradings, water and consistency, batching and mixing, estimating quantities of materials, form work, steel reinforcement, placing and curing concrete, cold weather methods, expansion and contraction joints, finishing concrete surfaces, mortar and stucco, producing watertight concrete, and various other details.

Louisiana Highway Report

Sixth Biennial Report of the Louisiana Highway Commission, covering the period from April 20, 1930, to April 20, 1932. Heavy paper cover, 524 pages, 6 by 9 in. Numerous halftones, plates, tables and inserts.

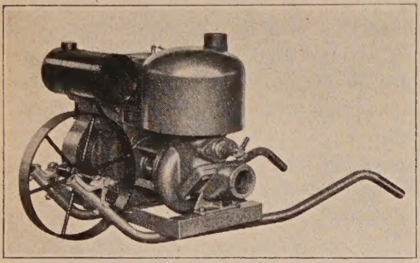
This report is of special interest, since it covers the period during which Louisiana actually constructed 1,493 miles of concrete pavement, as well as a number of major bridges. During 1931 the concrete pavement actually placed amounted to about 1,000 miles, exceeding the mileage in any other state.

New Equipment and Materials

Self-Priming, 2-In. Pump New Rex Unit

Many innovations producing astonishing performance for a pump in the 2-in. size are claimed for the new, low-priced unit added to its Speed-Primer pump line by the Chain Belt Co., Milwaukee, Wis.

The self-priming system is of the recirculating type which eliminates all such accessories as air pumps and foot valves. Once filled, this system is said to be absolutely automatic in its action. The recirculating system is built around a new device called the Rex Prime Control by which the system can be adjusted to any suction lift, assuring the fastest possible priming time and the greatest capacity possible for that lift.



In tests at the Chain Belt plant this new 2-in. pump has easily qualified for the A. G. C. ratings of 9,300 g.p.h. on a 10-ft. suction lift and the A. G. C. maximum suction lift rating of 25 ft.

Truck Mixer for Highway Widening and Similar Uses

A truck mixer unit newly developed by the Jaeger Machine Co., Columbus, Ohio, is designed especially for use in highway widening, as well as curb and gutter work, sewer, sidewalk, and culvert construction, and general commercial concrete delivery.

Side discharge mounting, which is a feature of the unit, increases the distance from the truck center line at which concrete can readily be discharged and permits the use of the truck mixer and trailer mixer longitudinally of the work being placed.

The new dual discharge (discharged from either side of drum) will discharge either 2½- or 5-cu. yd. batches in less than one minute, and when used in connection with Jaeger concrete spreaders, the daily yardage on road work is limited only by the number of trucks operated and the amount of roadbed prepared to receive the concrete, according to the Jaeger company.

Combined use of truck mixer and mixer mounted on trailer, for which the side discharge is ideally adapted, is said to offer means of reducing the ton-mile cost with a minimum of investment.

Jaeger road builder truck mixers with dual side discharge are built in 2½- and 5-yd. capacities. A descriptive bulletin on these units has recently been published by the Jaeger Machine Co. and is available on request.

INDUSTRIAL LITERATURE

Flawless Concrete

Drawings of typical plywood forms, photographs of a number of types of construction for which plywood is especially suited, as well as deflection graphs and other test data are contained in a new bulletin issued by *Douglas Fir Plywood Manufacturers*, Seattle, Washington.

The leaflet is entitled *"How to Make Concrete Flawlessly Smooth at Low Cost,"* and is available to contractors and architects without charge.

Sodium Silicate Curing

The Sodium Silicate Manufacturers Institute, of which J. P. Elkinton, Philadelphia, Pa., is secretary, is now distributing a 64-page publication, *"Curing Concrete with Silicate of Soda."* It is for sale at $1.50.

This is a high-grade booklet, 8½ by 11 in. in size, apparently covering every phase of the use of this curing agent.

From Pyramid to Incor

New Profits from Idle Days is the title of a new publication published under the signature of Waldemar Kaempffert for the *International Cement Corp.*, New York City.

Its story begins with the building of the Great Pyramid and the early use of cement, and concludes with the introduction of Incor, "a new era in cement."

The publication comprises 32 8½- by 11-in. pages, on dull-finish paper, and a dozen or more excellent illustrations.

Journal and Stock List

A new issue of the *Ryerson Journal and Stock List* has just been published. This handy reference book on steel, in addition to complete general descriptions, specifications, sizes, etc., contains the new extras on bands, the new cold finished steel extras, the new hot rolled cutting extras, and other information of value to the steel user.

Joseph T. Ryerson & Son, Inc., of Chicago, Jersey City and Boston, with plants in all the principal cities, will furnish copies on request.

Paper Bag Promotion

A series of news bulletins and the business papers are being used by the newly formed *Associated Manufacturers of Multi-Wall Sewn Paper Bags* to acquaint users with the economy and efficiency of this type bag.

Modern developments in cement manufacture such as finer grinding and high-early-strength products are said to make the paper bag more desirable than ever.

Nine manufacturers comprise the organization.

Westinghouse Tunnel

A construction feature in the George Westinghouse bridge near Pittsburgh is described in the June issue of *"Incor" News*, published by the makers of *Incor* and *Lone Star* portland cements.

The feature is the completion of a 600,000 cu. yd. fill two months ahead of schedule, made possible by the use of high-early-strength cement.

Joist Floors

The current folder of the *Concrete Reinforcing Steel Institute*, Chicago, Ill., is entitled *"Fine Examples of Concrete Joist Floor Adaptation to Residences, Small Buildings and Exposed Ceilings."* Photographs of residences, a garage, stores and other similar buildings having typical installations are shown in this 4-page leaflet.

Haynes Publication

"Turning Wishbones into Backbones," "Invention Carries On," "When 'Saving' Means 'Wasting'," and "Don't Sell Out—Get Out and Sell," are some of the titles over matter contained in the current issue of *"The Future of Industry."*

This is a publication of the *Haynes Corp.*, management engineers, Chicago.